PROCESS FOR PRODUCING ELECTRICAL CONTACTING PADS ON A SUBSTRATE AND DEVICE FOR CARRYING OUT THIS PROCESS

TECHNICAL FIELD

The present invention relates to the technical field of producing electrical connection pads, such as balls, on the surfaces of electronic components.

The present invention relates more particularly to a process for producing at least one electrical contacting pad on a receiving zone of an electronic component, in which a liquid alloy or metal is injected into at least one channel comprising two portions, a feed portion and a molding portion which are separated by a narrowing, said channel being positioned in such a way that the molding portion opens on the receiving zone.

The present invention also relates to a device for producing at least one electrical contacting pad on a receiving zone of an electronic component, said device comprising a channel for conveying liquid alloy or metal, said channel itself comprising two portions, a feed portion which is part of a first part forming a die, and a molding portion which is part of a second part forming a mold, said feed and molding portions being separated by a narrowing.

PRIOR ART

There are several techniques for connecting an integrated circuit, or more generally an electronic component, to a substrate or support. Examples are wire connections, ribbon connections and connections by arrays of microballs (BGA or Ball Grid Arrays) which provide the contact between the circuit and the support. The concept of interconnection by ball grid arrays finds particular favor for the high performance

it provides, with little in the way of parasitic effects.

A major challenge in the fabrication and laying of arrays of connection contacting pads is how to minimize the number of production operations and their duration, the aim being to be able to provide a substrate with contacting pads in the shortest time possible, without sacrificing the metallurgical and geometrical quality of the contacting pads.

French patent application registered under the number FR-99 05544 discloses a process for producing balls on an electrically conducting receiving zone of an electronic component, in which process:

- a conducting liquid alloy is injected into a guide composed of two separable parts, a mold and an injection-molding die, with a narrowing of the guide at the separation between the parts;
- the parts of the guide are separated while the alloy is liquid;
- the mold is separated from the substrate of the component before the alloy solidifies.

The same document also discloses a device for carrying out the abovementioned process.

Although such a process is generally satisfactory and tends to meet the challenge mentioned above, it nevertheless requires a large number of operations, which in turn necessitate complex control systems and require numerous parts moving relative to each other, with increased opportunities for wear and sticking, or poor precision in the production of the contacting pads.

The present invention also relates to a process for

regenerating a plurality of electrical contacting pads produced on receiving zones of an electronic component, in which a liquid alloy or a liquid metal is injected into at least one channel comprising two portions, a feed portion and a molding portion which are separated by a narrowing, said channel being positioned in such a way that the molding portion opens on the receiving pad.

Lastly, the present invention relates to a device for regenerating a plurality of contacting pads produced on receiving zones of an electronic component, said device comprising a channel for conveying liquid alloy or metal, said channel itself comprising two portions, a feed portion which is part of a first part forming a die, and a molding portion which is part of a second part forming a mold, said feed and molding portions being separated by a narrowing.

Sometimes, especially with ball deposition processes of the prior art, such as those using a sucker or screen to deposit the balls on the receiving pads of the component, or such as those involving reflow of solder cream screenprinted onto the receiving zone of the component, some balls, by the end of the process, have imperfections which reduce their serviceability, such as being malformed, or too small, or even simply absent. Inspection devices for spotting such defects or missing balls are known. After inspection it is usually necessary to correct any identified faults individually, by adding balls one by one where there are none, and removing balls that are too small and replacing them one by one with new balls with the desired characteristics. This is a time-consuming way to proceed and necessitates a large number of operations, making it an expensive and difficult technique to implement.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a novel process for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on a receiving zone of an electronic component, that provides a solution to the various drawbacks enumerated above and that is capable of producing electrical contacting pads or regenerating a plurality of electrical contacting pads faster, more simply and more economically.

Another object of the invention is to provide a novel process for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on a receiving zone of an electronic component, the reliability of which is improved.

Another object of the invention is to provide a novel process for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on a receiving zone of an electronic component, capable of producing electrical contacting pads with excellent reproducibility of shape.

Another object of the invention is to provide a device for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on a receiving zone of an electronic component, which is of simplified design and of improved kinematics and robustness.

Another object of the invention is to provide a novel device for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on a receiving zone of an electronic component, with good reproducibility and homogeneity.

Another object of the invention is to provide a novel device for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on receiving zones of an electronic component, capable of producing contacting pads of improved quality.

The objects of the invention are achieved by means of a process for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on receiving zones of an electronic component, in which:

- a liquid alloy or metal is injected into at least one channel comprising two portions, a feed portion and a molding portion which are separated by a narrowing, said channel being positioned in such a way that the molding portion opens on the receiving zone,
- the molding portion is separated from the receiving zone before complete solidification of the metal or alloy, while the feed and molding portions remain joined,

which process is characterized in that the feed portion is part of a first part forming a die, and the molding portion is part of a separate second part forming a mold, said die and mold being juxtaposed to form the channel.

The objects of the invention are also achieved by means of a device for producing at least one electrical contacting pad on a receiving zone of an electronic component, or for regenerating a plurality of electrical contacting pads produced on receiving zones on an electronic component, said device comprising a channel for conveying liquid alloy or metal, said channel itself comprising two portions, a feed portion which is part of a first part forming a die, and a molding portion which is part of a second part forming a mold, said feed and molding portions being separated by a narrowing, which device is characterized in that it comprises a means for fixing the die relative to the mold, allowing said die and mold to be juxtaposed in a fixed manner to form the channel.

BRIEF DESCRIPTION OF THE DRAWINGS

Other particular objects and advantages of the invention will become more apparent on reading the following description, and on consulting the drawings attached at the end, purely by way of non-restrictive illustration, in which:

- figures 1 to 3 schematically illustrate different phases in the process according to the invention, and certain parts of the device in accordance with the invention;

- figure 4 schematically illustrates, in cross section, a detail of the device in accordance with the invention, in a configuration corresponding to the process step shown in figure 1; and

- figure 5 schematically illustrates an embodiment of the channel of the device according to the invention.

PREFERRED EMBODIMENT OF THE INVENTION

Figures 1 to 3 illustrate different steps in the process for producing at least one electrical contacting pad 1 on a receiving zone 2 of an electronic component 3, in accordance with the invention.

The electronic component 3 is made of any material well known to those skilled in the art, and comprises electrically conductive receiving zones 2 which generally consist of metal tracks of copper or gold, for example.

In the process according to the invention a liquid alloy or metal 4 is injected into at least one channel 5.

Of the alloys that are useable in the process according to the invention, alloys combining two or more of the elements Sn, Pb, Bi, and In may be cited purely by way of non-restrictive illustration.

The channel 5 comprises two portions 5A, 5B, namely a feed portion 5A and a molding portion 5B, these two being separated by a narrowing 5C.

Figures 1 to 4 show a process and device that use, purely for illustrative purposes, four channels. In practice there will be as many channels 5 as there are contacting pads 1 to be produced, which means in practice that there are generally several tens or hundreds of them.

The liquid alloy or metal 4, which constitutes the solder material, may be injected by applying, by any known means, an injection pressure to said liquid solder material 4 to force it through the channel 5 towards the receiving zone 2, in an injection direction

shown in figure 1 by arrow I.

The feed portion 5A is continued by the molding portion 5B in such a way as to form a continuous channel 5 through which the liquid alloy or metal 4 will in overall terms follow an essentially one-way path, in the injection direction I.

As shown in the figures, the feed 5A and molding 5B portions may be straight and have common axial symmetry about an axis X-X'. Another possibility that does not depart from the scope of the invention is for the respective axes of symmetry of the feed 5A and molding 5B portions to be offset from each other rather than coinciding. In the variant shown in the figures, the feed 5A and molding 5B portions are basically cylindrical, the feed portion 5A having a constant cross section that is smaller than the (likewise constant) cross section of the molding portion 5B. The narrowing 5C arises in this case from the difference in cross section between the feed portion 5A and the molding portion 5B. The narrowing 5C refers here and in the remainder of this text to a restriction of the cross section of the channel 5 when the latter is traveled in the opposite direction to the injection direction I, i.e. from the molding portion to the feed portion.

It is possible to envisage other embodiments of the channel without departing from the scope of the invention. It is thus possible for both the feed 5A and molding 5B portions to be frustoconical in shape, with the cone portions meeting at their point of least cross section, to produce a neck forming a narrowing 5C. Another possibility is for the feed portion 5A to be a right cylinder feeding into the point of least cross section of a molding portion 5B of frustoconical shape. Another possibility is for the molding portion 5B to be

basically hemispherical or concave, with an opening communicating with a feed portion 5A of cylindrical or frustoconical shape. Such embodiments and geometries of the channel 5 are well known to those skilled in the art, notably from document FR-99 05544. Still another possibility, as is shown in figure 5, is for the narrowing 5C to be produced by the relative sideways offsetting of the feed 5A and molding 5B portions. In this way, the respective cross sections of the feed 5A and molding 5B portions may be of any dimensions, as they need simply be partly overlapped to create the narrowing 5C. In this embodiment, one feed portion 5A can thus supply multiple molding portions 5B.

According to the invention, the channel 5 is so positioned that the molding portion 5B opens on the receiving zone 2.

The step described above thus constitutes a step of injecting liquid alloy or metal 4 onto a receiving zone 2. At the end of this step the injection pressure on the liquid alloy or metal 4 is discontinued.

In a subsequent demolding step, and in accordance with an essential feature of the invention, the molding portion 5B and the receiving zone 2 are separated before complete solidification of the metal or alloy 4, while the feed 5A and molding 5B portions remain joined.

The reason for this is that the applicant has found that it is possible, unexpectedly, to demold in the liquid phase but without - and in this it goes against the prior art - first performing a step of separating the feed portion 5A from the molding portion 5B. This demolding step, illustrated in figure 2, thus makes it possible, in one operation rather than two as in the prior-art processes, to obtain primary contacting

pads 1A that are separated from the remaining material 4 present inside the feed portion 5A, and this before complete solidification of the metal or alloy 4 forming said primary contacting pad 1A.

The expression *"before complete solidification"* here means that the material is in a liquid or at least highly malleable state that cannot be likened to the solid state. More precisely, in the case of an alloy, the state *"before complete solidification"* corresponds to a state situated outside of the *"completely solid"* region defined by the solidus curve in the liquid-solid phase diagram of the alloy in question.

The channel 5 may be machined all the way through one piece of material. Preferably, however, the channel 5 is constructed from two separate parts 6, 7. Thus, the feed portion 5A is part of a first part forming a die 6, and the molding portion 5B is part of a separate second part forming a mold 7, said die 6 and mold 7 being juxtaposed to form the channel 5, as shown in figures 1, 2 and 4. The mold 7 is thus pressed against the die 6 to create a continuous channel 5, in the same way as if the channel 5 had been machined from a single piece of material. The juxtaposition of two separate parts, such as the mold 7 and the die 6, necessarily however creates a gap at the contact interface 8 between these two parts. This gap, even if infinitesimal, creates an air film that actually proves beneficial to the demolding phase shown in figure 2, because it helps separate the material forming the primary contacting pad 1A from the material remaining in the die inside the feed channel 5A. The juxtaposition of two separate parts 6, 7 to form a single whole is thus a particularly useful embodiment of the channel 5.

Advantageously, the liquid alloy or metal 4 is moved in

the opposite direction to that of injection (the reflux direction, indicated by arrow R) through the feed portion 5A, before the molding portion 5B is separated from the receiving zone 2. This reflux step, which takes place between the injection step shown in figure 1 and the demolding step shown in figure 2, makes it possible to break, at the narrowing 5C and in cooperation with this narrowing, the "column" of liquid alloy or metal 4 present in the channel 5, thus facilitating and optimizing the demolding operation by allowing precise control over the amount of material deposited on the receiving pad 2 in order to form the primary contacting pad 1A.

As a matter of preference, the alloy 4 is moved in the reflux direction R by suction, by applying a pressure in the opposite direction to that of injection, i.e. a partial vacuum, to the liquid alloy or metal 4.

As a matter of preference, the suction is created by moving, in the opposite direction R to the injection direction, a poppet valve-type close-off element 9 situated upstream of the channel 5 when considered in the injection direction I, towards a position in which said close-off element 9 closes the liquid alloy or metal 4 supply to the channel 5. The close-off element 9 thus has two functions: it closes off the supply to the channel 5 and thus ends the injection step, and its movement through the liquid alloy or metal 4 creates a partial vacuum that causes an appreciable movement of the liquid alloy or metal 4 through the feed portion 5A in the reflux direction R.

At the end of the demolding step, or almost at the same time as this demolding step, the liquid alloy or metal forming the primary contacting pad 1A finds itself no longer under any mechanical influence except for that of the receiving zone 2 on which it is resting. It will

thus adopt the shape of an approximately spherical cap, as shown in figure 3, the geometry which minimizes the surface tensions. It is in this step of contacting pad formation the liquid alloy or metal will now cool and solidify completely.

It is of particular advantage for the separation of the molding portion 5B from the receiving zone 2 to take place in a blanket of inert or reducing gas G. The gas G preferably begins to be applied before the beginning of the demolding step shown in figure 2 in order that the demolding operation can take place in a gaseous environment that will inhibit contacting pad oxidation.

The gas G preferably comprises nitrogen. The gas G may however comprise any other inert or reducing gas that performs the oxidation inhibiting function.

The gas G advantageously comprises a component containing a carboxyl group (COOH) as the presence in the gas G of such a component gives it properties that help the formation of the contacting pad 1 from the primary contacting pad 1A, allowing the balls 1 to form rapidly with good shape repeatability. It is strongly preferable for the carboxyl group-containing component to be formic acid (H-COOH). The gas G thus forms an active atmosphere that has two functions, namely an antioxidation function and a contacting pad shaping function 1.

The device for producing at least one electrical contacting pad 1 on a receiving pad 2 of an electronic component 3 in accordance with the invention comprises a channel 5 for carrying liquid alloy or metal 4. As described earlier, said channel 5 itself comprises two portions, a feed portion 5A belonging to a first or die part 6, and a molding portion 5B belonging to a second or mold part 7, which is preferably separate from the

first part. Said feed 5A and molding 5B portions are separated by a narrowing 5C.

An essential feature of the device according to the invention is that it comprises a means 10 of fixing the die 6 relative to the mold 7, allowing said die 6 or mold 7 to be juxtaposed in a fixed manner to form the channel 5. The die 6 and the mold 7 are thus assembled to form an unitary one-piece subassembly.

The die 6 advantageously includes a plate comprising at least one porous region that forms the feed portion 5A. The die 6 can thus be made from a porous material whose porosity is inhibited by etching, lacquering or any other process familiar to those skilled in the art, except in regions forming the feed portion 5A.

The mold 7 can be produced by any process known to those skilled in the art. The material of the mold 7 is preferably chosen so as not to wet the liquid alloy or metal 4, and to minimize the surface tension between the alloy and the mold. The material may be chosen from, in particular: stainless steel with chemical deburring, graphite, PTFE, and treated silicon.

The device according to the invention advantageously comprises, upstream of the die 6 when considered in the direction I of flow (or injection) of the liquid alloy or metal 4, a reservoir 11 designed to contain the liquid alloy or metal 4, said reservoir 11 having a lower opening 11A feeding into a sump 12 which in turn communicates with said die 6. The movement of the liquid alloy or metal 4 through the lower opening 11A is controlled by a poppet valve-type moving close-off element 9 able to move parallel to the direction of flow of the liquid alloy or metal 4, in the injection direction I or in the opposite reflux direction R, between an upper contact position (not shown) in which

it closes the lower opening 11A, and at least one intermediate position (shown in figure 4) in which it allows the liquid alloy or metal 4 to flow through to the sump 12 and then on to the die 6.

The poppet valve-type moving close-off element 9 preferably comprises a stem 9A and a head 9B whose cross section is greater than that of the stem 9A. The stem slides vertically between the edges of the opening 11A, with sufficient clearance from said edges to allow the passage of the liquid alloy or metal 4. The opening 11A widens out downstream when considered in the injection direction I, to form a chamber in which the head 9B moves. The die 6 is in leaktight (seal 13) communication with this chamber to form the sump 12. The head 9B thus moves within the liquid alloy or metal contained within the sump 12, and can impart to this material a direction of flow into the feed portion 6. When the head 9B is held against the peripheral lip of the opening 11A, the supply of liquid alloy or metal to the sump 12 is stopped, the material simultaneously experiencing suction in the wake of the head 9B.

Such a poppet valve-type arrangement thus makes it possible to carry out the step of injection stoppage and suction referred to earlier in the description of the process.

The device according to the invention advantageously comprises a means (not shown) for dispensing a gas G around the molding portion 5B. This gas dispensing means is used to saturate the atmosphere with a gas G that is preferably inert or reducing, to perform an antioxidation function. Said gas G also preferably comprises a component containing a carboxyl group (COOH), so as to have properties of shaping the balls 1 with good repeatability. The carboxyl group-containing component is preferably formic acid (H-COOH). The gas G

preferably includes nitrogen.

The gas G dispensing means (not shown) advantageously comprises a diffusion means (not shown) and, situated upstream of said diffusion means, a production means (not shown), said diffusion means allowing the carboxyl group-containing component to be imbibed by a primary inert or reducing gas. The dispensing means preferably comprises, by way of production means, a receptacle containing liquid formic acid which will be placed in contact with nitrogen so that the nitrogen imbibes formic acid and thus has the qualities described earlier.

The channel 5 is advantageously designed to be positioned above the receiving zone 2. This technical feature is totally independent of whether the mold and die are formed in one piece or from two separate parts. This specific arrangement gives particularly good results, no doubt because any impurities present in the liquid alloy or metal 4 and which are usually less dense than the liquid alloy or metal 4, drift upward in the reflux direction R under the effect of gravity and do not collect on the contacting pad surface 14 in contact with the receiving zone 2 where they could interfere with correct wetting of the contacting pad 1A and its good adhesion to the receiving zone 2. This arrangement also prevents impurities collecting under the effect of gravity in the molding portion 5B and/or feed portion 5A where they could block up said portions 5A, 5B.

Totally independently, therefore, the invention relates to a process for producing at least one electrical contacting pad 1 on a receiving zone 2 of an electronic component, or for regenerating a plurality of electrical contacting pads 1 produced on receiving zones 2 of an electronic component 3, in which a liquid

alloy or liquid metal 4 is injected into at least one channel 5 comprising two portions, a feed portion 5A and a molding portion 5B which are separated by a narrowing 5C, said channel 5 being positioned in such a way that the molding portion 5B opens on the receiving zone 2, said process also comprising a step in which the molding portion 5B is separated from the receiving zone 2 before complete solidification of the metal or alloy 4, while the feed 5A and molding 5B portions remain joined, said channel 5 being designed to be positioned above the receiving zone 2 relative to gravity.

The invention also relates independently to a device for producing at least one electrical contacting pad 1 on a receiving zone 2 of an electronic component 3, or for regenerating a plurality of electrical contacting pads 1 produced on receiving zones 2 on an electronic component 3, said device comprising a channel 5 for conveying liquid alloy or metal 4, said channel 5 itself comprising two portions, a feed portion 5A which is part of a first part forming a die 6, and a molding portion 5B which is part of a second part forming a mold 7, said feed 5A and molding 5B portions being separated by a narrowing 5C, said device comprising a means 10 for fixing the die 6 relative to the mold 7, allowing said die 6 and mold 7 to be juxtaposed in a fixed manner to form the channel 5, and said channel 5 being designed to be positioned above the receiving zone relative to gravity.

The process and device according to the invention can also be used to regenerate a plurality of electrical contacting pads 1 produced on receiving zones 2 of an electronic component 3. The term *"regenerate"* here denotes broadly a contacting pad repairing operation involving in particular, if appropriate, the addition of material to correct or complete the dimensions of

the contacting pads, and/or reshaping of contacting pads. For this purpose the same steps as are followed when producing new contacting pads according to the process described above are followed in order to rehabilitate ball grid arrays 1 that have defects (particularly geometrical). The first regeneration step is thus to press the channel 5 onto the receiving zone 2 so that it sits over the existing contacting pad 1 that requires correcting. A liquid alloy or metal 4 is then injected into the channel 5 and fills up, inside the molding portion 5B, whatever space is left unoccupied by the existing defective contacting pad 1. In this way corrective overmolding of the defective contacting pad is performed.

The device and process in accordance with the invention thus make it possible quickly to produce or regenerate BGA-type arrays of electrical contacting pads 1, since the number of steps is optimized (there is no step of separating the mold from the die), as is the cycle time, because there is no need to wait for the material to solidify inside the molding portion 5B before demolding.

INDUSTRIAL APPLICABILITY

The invention has an industrial application in the production of electrical contacting pads.